The Future of Space Exploration: Relevance, Return and Relationships

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Planetary Probe Workshop
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Why Explore or Utilize Space?

- **Hubbard's reasons (November, 2003):**
  - **Major scientific discoveries: "Where did we come from?"; "Are we alone?"**
  - **National Interest: US leadership**
  - **New technology or business enterprise: Return on Investment**
  - **International cooperation for peaceful purposes: International Space Station**
  - **A hedge against future catastrophe: A second home for humanity**

- **Len Fisk, Chair of the National Academy of Science Space Studies Board (March, 2008):**
  - **"It should be possible to provide NASA with a role that is not only about the future, but is important in the present. Perhaps it is a more important geopolitical role, cooperatively leading the nations of the world in the exploration of space, and by doing so improving the image of the United States. Perhaps it is a more important role in improving the competitive position of the United States. Or simply reemphasizing the programs that are of demonstrable immediate importance to the taxpayers: Earth**

Examining the Vision for Space Exploration Workshop Consensus Statements:

- Human space exploration is undertaken to serve national and international interests. It provides important opportunities to advance science, but science is not the primary motivation.

- It is time to go beyond LEO with human explorers. The purpose of sustained human exploration is to go to Mars and beyond. The significance of the Moon and other intermediate destinations is to serve as steppingstones on the path to that goal.

- Sustained human exploration requires enhanced international collaboration and offers the United States an opportunity for global leadership.

- NASA has not received the budget increases to support the mandated human exploration program as well as other vital parts of the NASA portfolio, including space science, aeronautics, technology development, and especially Earth observations, given the urgency of global climate change.

Relevance, Return and Relationships

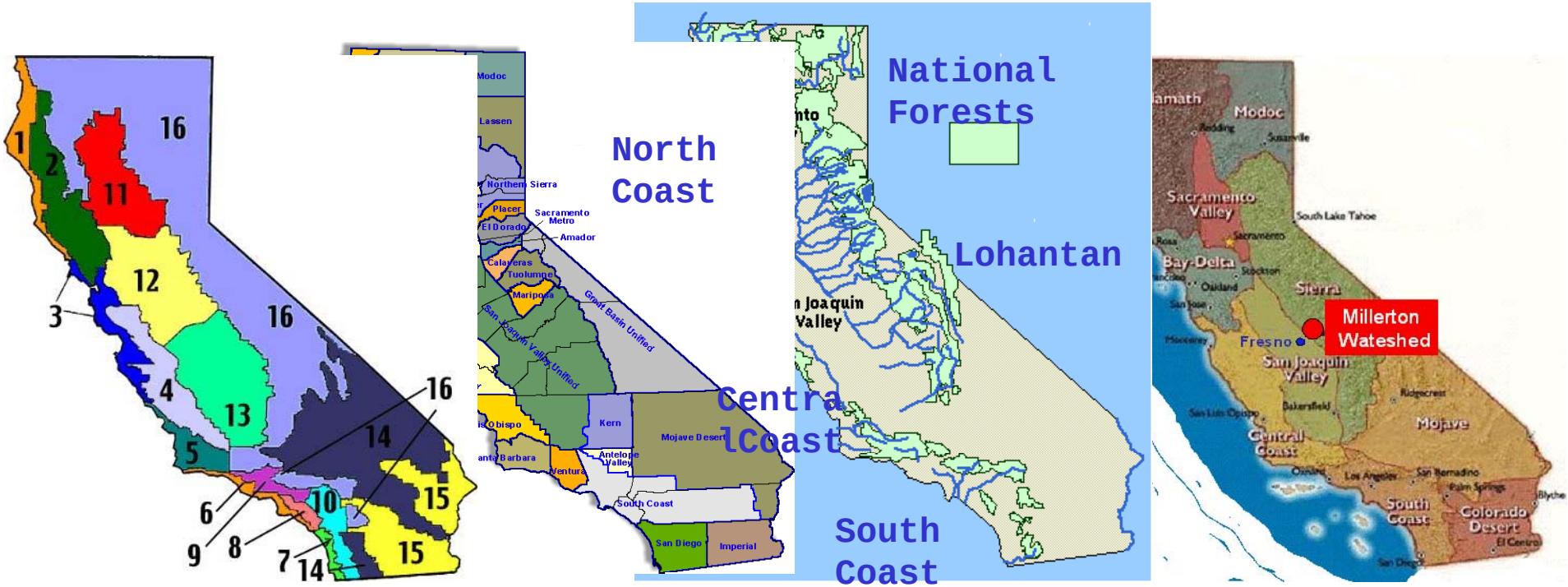
- **Relevance to the taxpayer**
  - **Earth Science and Alternative Energy**
    - **Remote sensing platforms to provide both global and regional climate change data for policy makers (plus comparative planetology)**
    - **Utilization of Space Solar Power**
  - **Aeronautics**
    - **Restructuring the nation's airspace; increasing capacity, maintaining safety and reducing emissions**
- **Return on Investment - new players**
  - **Space Tourism and COTS**
    - **Human suborbital 5-8 years; Cargo orbital soon, people eventually**
  - **Utilization of the microgravity environment**
    - **Pharmaceutical, Biomedical and Materials Science**
- **Relationships - new programs**
  - **International Robotic Mars Sample Return Mission**
  - **International Outer Planets Exploration**
  - **International Human Lunar and Mars Exploration**

Relevance: Regional Climate Change

Think globally, Forecast regionally, Act l

Assessing and addressing the impacts of climate change in California

Climate **Air** **Water** **Bio**



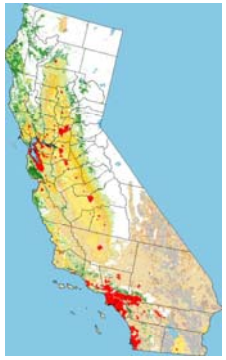
Beyond the capacity of today's global models

California Regional Climate Change Concept

Decide science questions--Follow the Water

Collect and fuse data at regional scale

SNOW COVER



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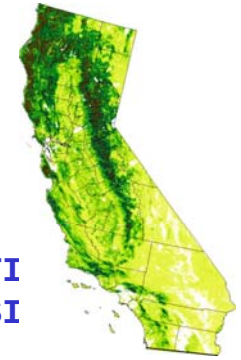

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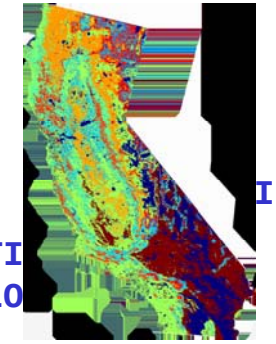

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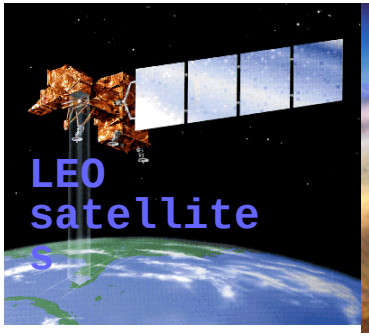
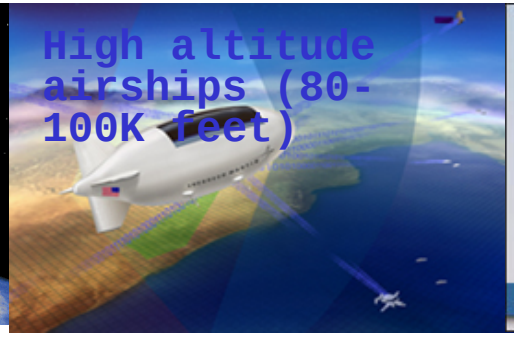
– Fill in gaps with new platforms



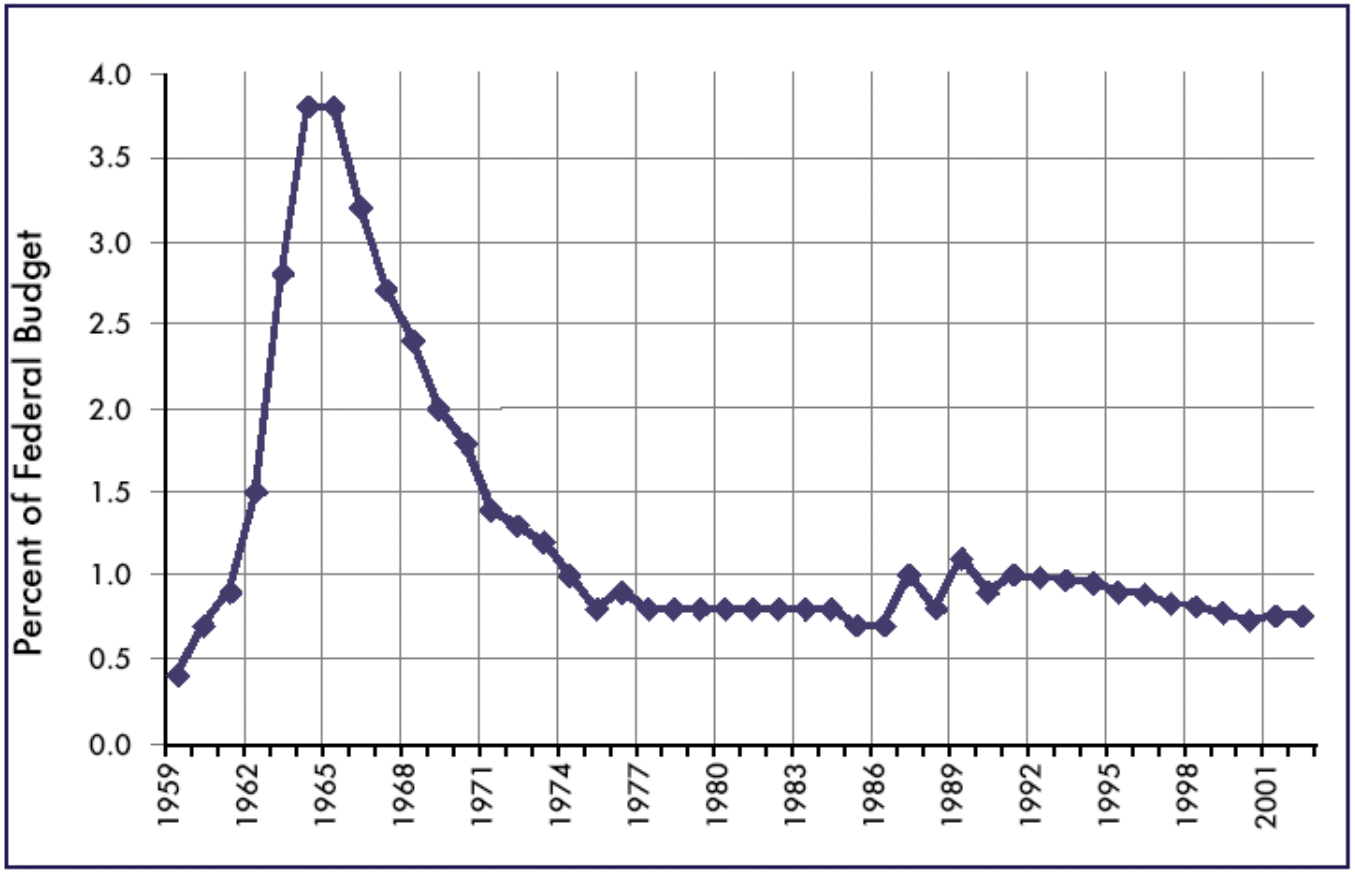


Space Solar Power - An Idea That Has Arrived?

- **The Payoff**
  - **24/7 Power Availability**
  - **Environmentally Clean**
- **Technology Challenges:**
  - **Low Cost Launch**
  - **Lightweight Materials**
  - **On-orbit assembly**
  - **Efficient Energy Conversion and Transmission**

NASA's Budget Dilemma

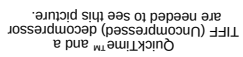
- Since the early 1970's, NASA has received 20% or less of the funding available to it during the Apollo Program



- Future exploration requires a new base of investment so that NASA can leverage its flat budget by getting out of the LEO business

The $250B Worldwide Space Enterprise

Commercial space now dominates worldwide space expenditure - opportunities are growing



Courtesy Space Foundation

Entrepreneurial Space is Hot!!

Falcon I at SpaceX launch pad at Vandenberg Air Force Base
Founder/CEO-Elon Musk

Bigelow Aerospace inflatable habitats-artist's conception
Founder/CEO-Bob Bigelow

Virgin Galactic has $20,000 deposits from > 100 tourists
Founder/CEO- Sir Richard Branson

SpaceDev develops commercial hybrid rocket motors and small space vehicles and subsystems.
CEO - Mark Sirangelo

Scaled Composites-Aerospace and specialty composites
Winner of the X-prize in 2004
President- Burt Rutan

Investor and philanthropist
Paul Allen

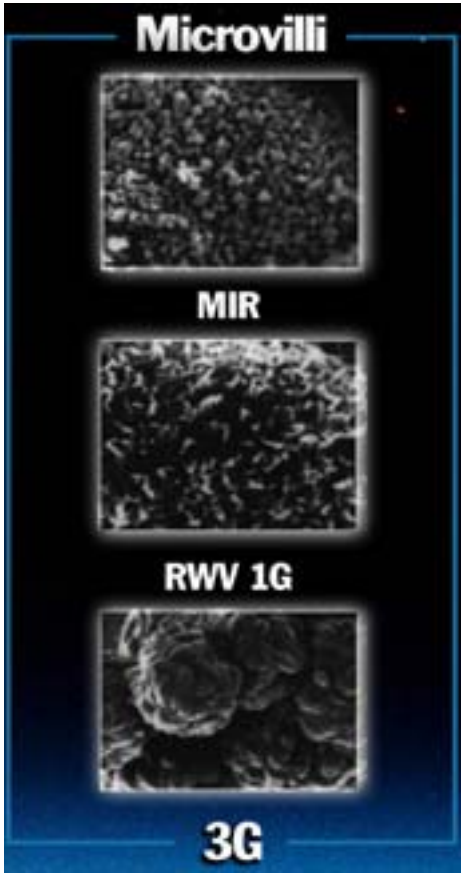
Suborbital Competition is Strong

Spaceship 2
Design Underway

XCOR Lynx
Just
Announced

European
entry: EADS
Astrium

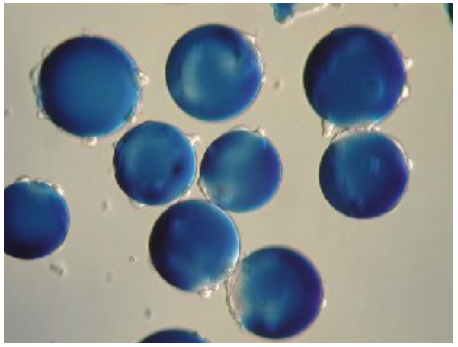
Sutter's Gold ?: Space Biological Research



Radically different gene expression (in renal cells)

Mammals show symptoms of aging, but recover on Earth

Unusual lignin (a compound vital to connective tissue) growth in plants



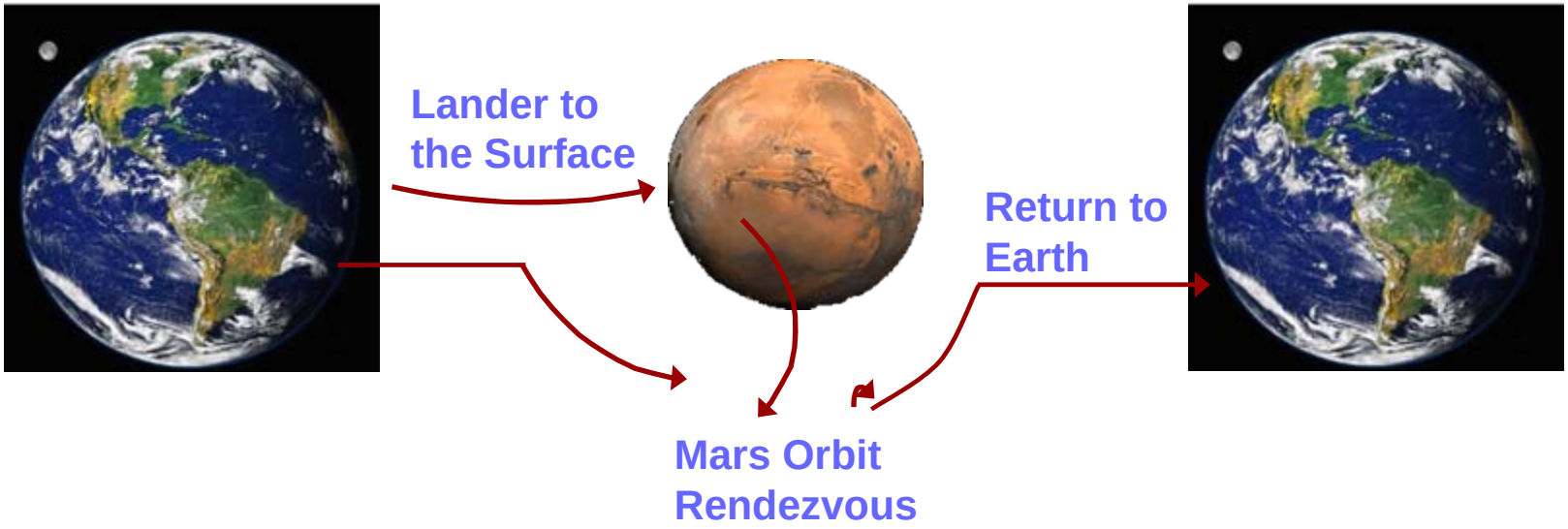
Superior cellular structural & biochemical properties (Stelsys)

Dramatic increase in infectivity

European and Japanese modules on the ISS are equipped for this kind of research

The Future - ISS as an International Lab?

Mars Sample Return: the most complex robotic mission ever undertaken:

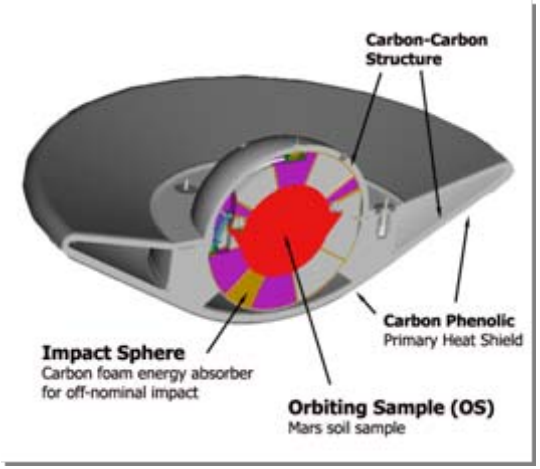


Cost: $5B+

International collaboration probable

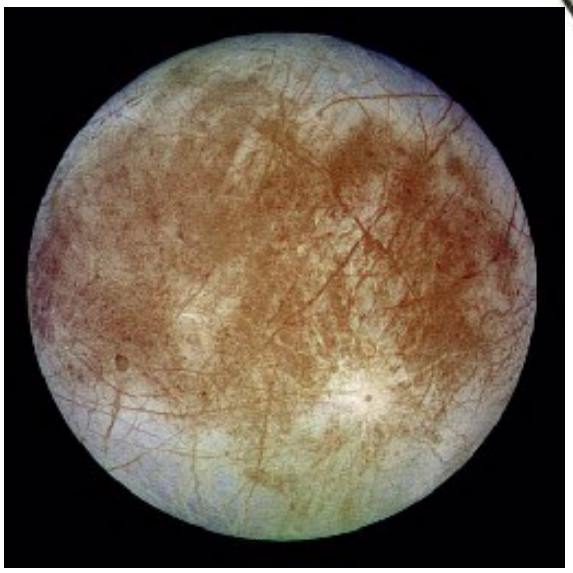
Multiple new developments required:

- On orbit autonomous rendezvous
- Mars ascent vehicle
- Sample return vehicle



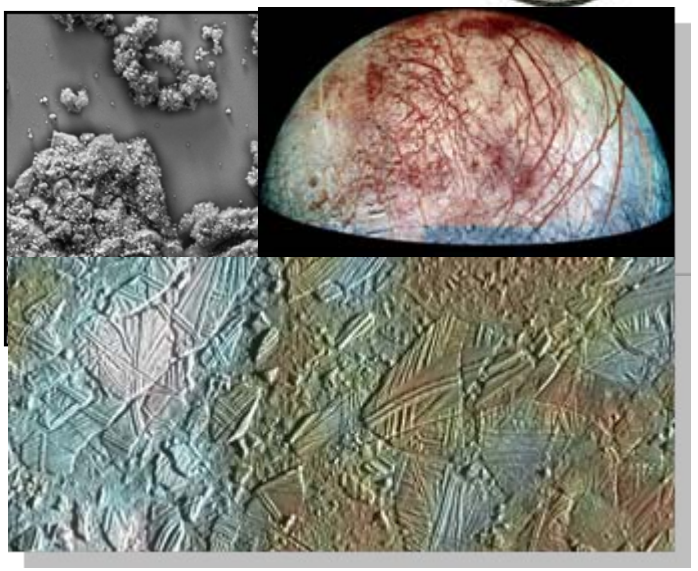
Outer Planet Flagship Mission - Context

- NASA is currently mid way through a six month long outer planet study which is being conducted jointly with the European Space Agency. Two missions are being studied
  - Europa Jupiter System Mission (EJSM
  - Titan Saturn System Mission (TSSM)
- NASA plans to down select to a single Outer Planet Flagship mission in November 2008 which will be pursued jointly with ESA and other international partners.



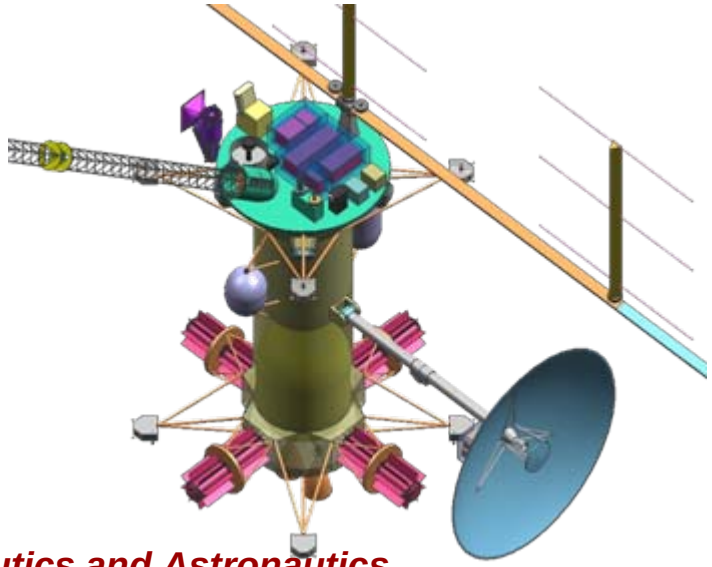
Europa Explorer 2006 Study

- In October 2005, JPL initiated an internal study with the goal of demonstrating that a **highly capable Europa orbital mission was feasible with current technology**



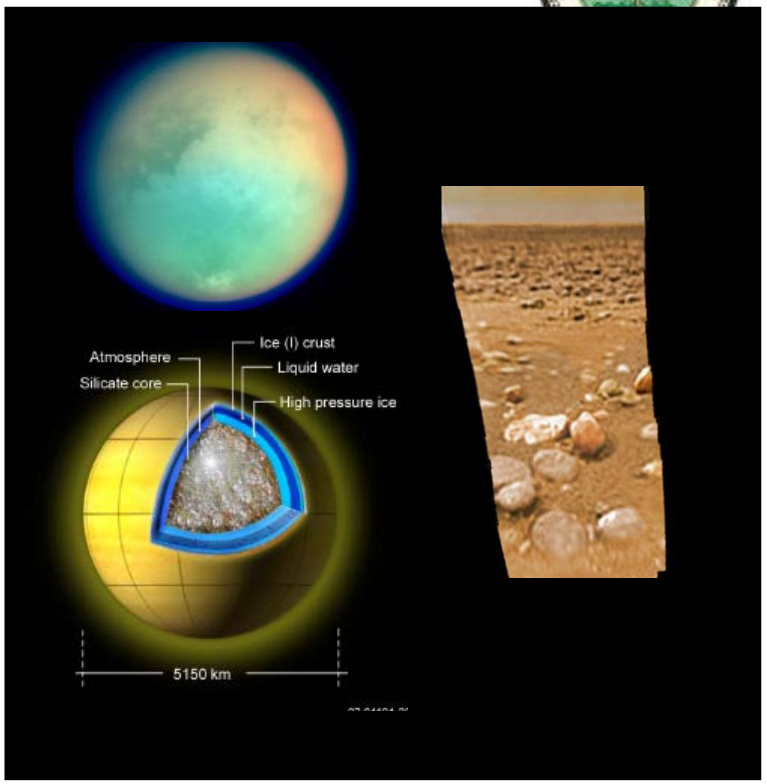
- The mission includes an extended Jupiter orbital phase with observations of Jupiter and the other Galilean satellites

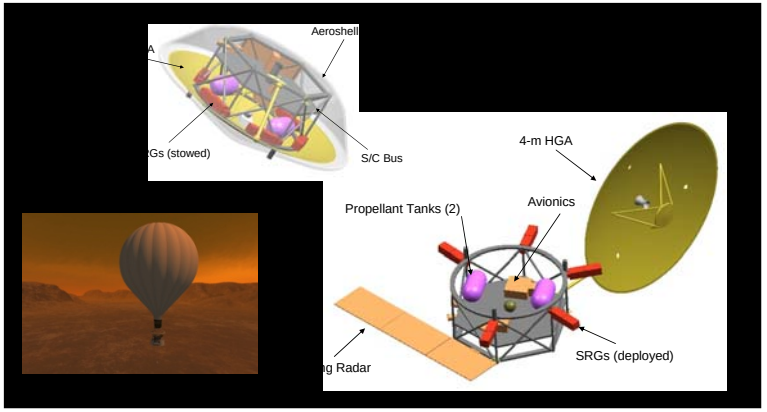
- The study was very successful and NASA adopted the JPL Europa Explorer concept when it initiated the Phase 1 Outer Planet Flagship study in October 2006



Titan Pre-biotic Explorer 2006 Study

- In October 2006, JPL initiated an internal study with the goal of demonstrating that a highly capable Titan exploration mission incorporating orbital, atmospheric and surface science is feasible with current technology
- The mission included an orbiter for global science and data relay, and an in situ Montgolfiere element with lower atmosphere and surface science including surface sampling from 10 or more site
- The study was very successful and fed directly into NASA's 2007 TE study which examined this concept further





NASA-ESA 2008 Outer Planet Flagship Studies Decision Process

Submitted 8/07

Down-selected 12/07

Key 2008 Milestones

Initial Instrument Workshop……June 3-5, 2008
Initial Report due to HQ……..Aug 4, 2008
Site Visit…… ……..Sept 9,11, 2008
Final Report……..Oct 22, 2008
Final down-select ……Nov. 21, 2008

http://opfm.jpl.nasa.gov

Down-select 11/08

Titan Saturn System Mission
or
Europa Jupiter System Mission

Key Aspects

- International cooperation integral to both concepts
  - ESA is primary international partner
  - JAXA, RSA, ESA member-states may participate
- JPL leads partnership with APL, other NASA centers
- President's FY09 budget: funding begins in FY09

The Future of Space Exploration, Searching for Life with Humans and Robots Together